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USAARL REPORT NO. 73-14

REAL-EAR SOUND ATTENUATION CHARACTERISTICS OF THE SIERRA P/N 791 AVC HELMET

By

Robert T. Camp, Jr.
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Ben T. Mozo
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June 1973

U. S. ARMY AEROMEDICAL RESEARCH LABORATORY
Fort Rucker, Alabama

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U. S. Army Medical Research and Development Command

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ABSTRACT

The U. S. Army Aeromedical Research Laboratory was requested by the Preventive Medicine Division of the Office of The Surgeon General to test "off-the-shelf" helmets that would be suitable for the replacement of the standard T-56-6 CVC helmet. Previous evaluation by real-ear tests of sound attenuation established the T-56-6 to be an inadequate hearing protector for armored vehicle crewmen.

Three "off-the-shelf" helmets were tested and recommended as suitable for consideration as a possible replacement for the standard CVC helmet. The DH-132 was identified by the Armor Center as their choice of the three presented helmets as being most appropriate for the armor environment. The DH-132 has been tested and accepted as a standard helmet for armored vehicle crewmen. Recently another helmet, the Sierra P/N 791 AVC helmet, has been submitted for consideration as a second helmet for armored vehicle crewmen.

The real-ear attenuation test results show that the Sierra helmet significantly failed the attenuation tests and therefore did not meet the attenuation requirements established by The Surgeon General. The Sierra helmet in its present configuration is not acceptable as a hearing protector for U. S. Army tank personnel.

APPROVED: Robert W. Bailey

ROBERT W. BAILEY
COL, MSC
Commanding

REAL-EAR SOUND ATTENUATION CHARACTERISTICS

OF THE SIERRA P/N 791 AVC HELMET

INTRODUCTION

In recent years, the U. S. Army Medical Research and Development Command has been concerned with the problems of providing helmets and other devices for hearing protection for Army personnel. Out of this effort came the development of the SPH-4 helmet for U. S. Army aviators. In 1970, the U. S. Army Aeromedical Research Laboratory was requested by the Preventive Medicine Division of the Office of The Surgeon General to provide information about the attenuation characteristics of some "off-the-shelf" helmets that might replace the standard T56-6 CVC helmet. Previously published data of real-ear attenuation characteristics of the standard helmet for armored personnel did not provide adequate protection against the high sound pressure levels within U. S. Army tanks.

During the development of the SPH-4 helmet the U. S. Army Aeromedical Research Laboratory tested various types of helmets. With this data available, the U. S. Army Aeromedical Research Laboratory selected and recommended three types of helmets that would fulfill the acoustic protection requirements of U. S. Army tank crewmen. These recommendations were published in USAARL Letter Report dated 25 May 1970, entitled: "Real-Ear Sound Attenuation Characteristics of Three Brands of Ear Protective Devices Proposed for Armored Vehicle Crewmen," that describes the real-ear attenuation data on three brands of helmets with ear protective devices, namely, 1) the David Clark HPG-9A, 2) the CBS Mark III, and 3) the Gentex DH-132. Of these three proposed helmets, the DH-132 was selected by Armored Center representatives as the most suitable for the tank crewmen. Since that time, the DH-132 has been tested and accepted as a standard helmet for armored personnel. In addition to the DH-132, the P/N 791 AVC helmet - manufactured by the Sierra Engineering Company, has been submitted for consideration as a standard helmet for tank crewmen. The Aeromedical Research Laboratory has been requested to measure the sound attenuation characteristics of this helmet as one part of the total responsibility of this Laboratory for evaluating the medical aspects of bump protection, thermal protection and acoustic protection. Results of the real-ear attenuation tests of the Sierra P/N 791 AVC helmet are contained in this report.

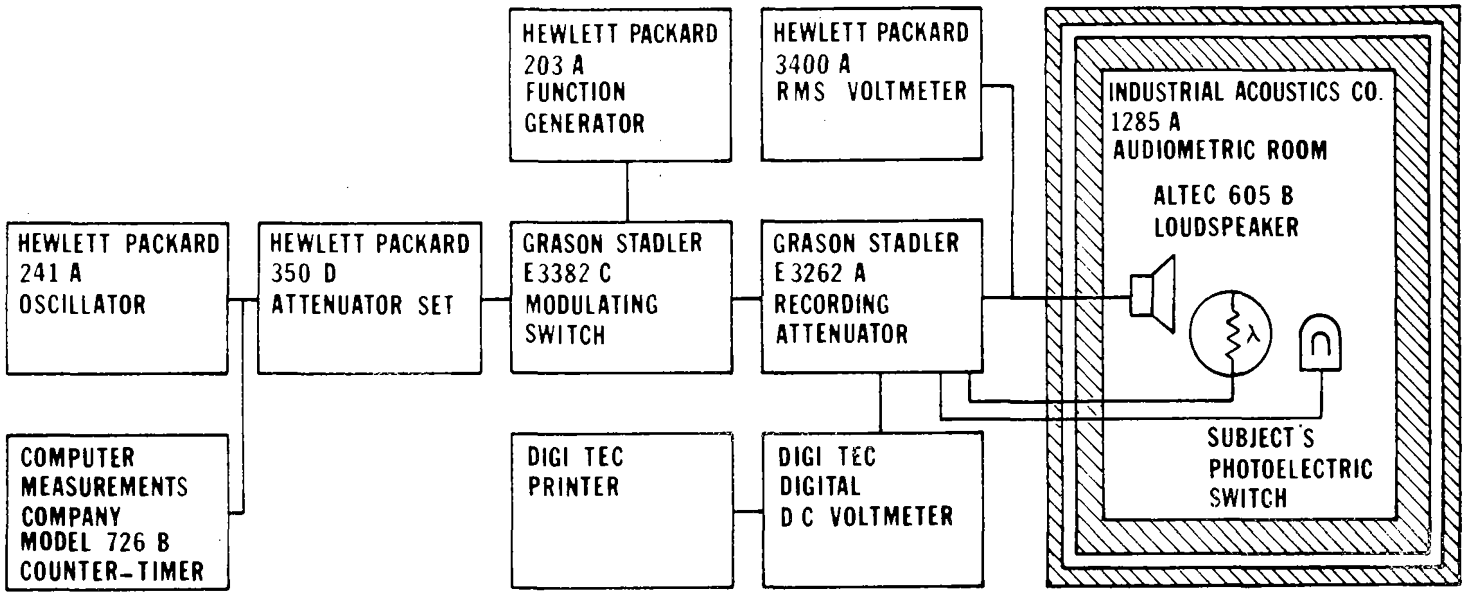
PROCEDURE AND EQUIPMENT

Procedures, equipment and physical requirements specified in the Standard Method for the Measurement of the Real-Ear Attenuation of Ear Protectors at Threshold, ANSI Z24.22 - 1957, were used for ascertaining the real-ear attenuation characteristics of the Sierra AVC helmet.

In addition to the standard 124, 250, 500, 1K, 2K, 3K, 4K, 6K and 8K Hz test frequencies, one lower test tone 75 Hz was included. The tones were generated by a Hewlett-Packard 241-A oscillator. See Block Diagram of instruments in Figure 1. The output of the oscillator was connected to a step attenuator set - a Hewlett-Packard 350D with a range of 110 dB in 1 dB steps. The attenuator provided the experimenter with a calibrated control of test tone levels for checking the subjects' reliability; also, the control of the overall sound pressure levels of test tones was necessary for subjects with extremely low thresholds and for boosting levels when testing attenuating devices of high efficiency. The output of the 350D attenuator was fed into the input of a Grason Stadler E-3382C modulating switch. The modulating switch served as a device for interrupting the test tones with a 50 percent duty cycle and with off and on durations of approximately 370 milliseconds which simulates the interruption rate of our Laboratory audiometer. The rise and decay times of the switch were 40 milliseconds each. The E-3382C modulating switch also served as a power amplifier for driving the loudspeaker. The Grason Stadler E-3262A recording attenuator was between the power amplifier and loudspeaker for recording attenuation and control of output level of the loudspeaker. The loudspeaker was an Altec 605B, a two-way duplex transducer with 15 inches diameter. The recording attenuator was provided with control switches that may be operated by the subject and the experimenter. The subject's switch was a photoelectric clickless type. The experimenter's switch had facilities for changing directions, stopping the attenuator and overriding the subject's control. Having the recording attenuator on the output of the power amplifier provides attenuation of the test signal and the amplifier noise. The voltage to the loudspeaker was measured with a Hewlett-Packard 3400A RMS voltmeter. The circuitry was calibrated with this voltmeter at the beginning of each test.

In addition to recording information on the recording attenuator, there was a digital printout of the attenuation values. A potentiometer was coupled mechanically to the recording attenuator which controlled a DC voltage as a function of attenuator setting. The voltage across the potentiometer was adjusted to indicate 1.000 volt on a Digi Tec digital DC voltmeter when the recording attenuator was set at 100 dB attenuation. By arbitrarily moving the decimal

Figure 1



BLOCK DIAGRAM OF INSTRUMENTATION FOR REAL-EAR ATTENUATION TEST

point, the voltage indication may be taken as a representation of the attenuation value of 100.0 dB. The linear relationship between the change of attenuation of the recording attenuator and the accompanying voltage across the potentiometer yields digital voltage readings that are numerically identical to the attenuation values registered on the recording attenuator. This information was printed by a Digi Tec printer which was connected to the digital voltmeter. This system of representing attenuation values with voltage readings has a resolution equivalent to one-tenth decibel.

The recording attenuator circuitry was provided with a one-shot monostable multi-vibrator circuit that sent a print command each time the subject changed recording attenuator direction. With a Bekesy type response for constant test tones, there was an oscillation of attenuation values around the subject's threshold. This oscillation is due to the activation and release of the attenuator control switch when the listener perceives and ceases to perceive the acoustic stimuli, respectively. The printout facility provided digital printout of minimum and maximum values of the oscillations around the subject's threshold. The printer also provided a sum total of the response values at the end of ten responses.

A quiet environment was provided by an Industrial Acoustic Company 1285-A double wall audiometric room. The intensity gradients were measured for certain test tones as required by ANSI Z24.22-1957. Tables I through III contain sound pressure levels measured with 1-inch increments along three axes from the subject's head. These were the normal maximal sound pressure values of each test tone after calibration. The 1285-A had extremely high attenuation characteristics throughout the audiospectrum. Table IV is a tabulation of one-third octave band statistical analysis of the room noise. The system noise of the instrumentation used to measure the room noise is also shown. The noise measuring instrumentation was a calibrated one-inch Bruel & Kjaer microphone, a Bruel & Kjaer audiofrequency spectrometer type 2112, a Bruel & Kjaer level recorder type 2305, and a Bruel & Kjaer statistical distribution analyzer type 4420. System noise measurements were done with the microphone cartridge replaced by a 50 pico farad capacitor.

RESULTS AND DISCUSSION

Real-ear attenuation values obtained with the sample of Sierra helmets are shown in Table V. This table also contains the minimum attenuation values required by the specifications. Comparisons of the mean attenuation obtained with the Sierra P/N 791 AVC helmet with the specifications show that the Sierra helmet attenuation values are

Table I

Sound Pressure Level Gradient Data Derived from Measurements of Ten Test Tones in the IAC 1285-A Audiometric Room at the Acoustic Laboratory, Fort Rucker, Alabama. The Values are Normal Maximum Sound Pressure Level Output, in Decibels (re 0.0002 Dyne/cm^2), from the Calibrated Instrumentation for Testing Real-Ear Attenuation.

Test Tones in Hz.	Distance in Inches Below the Normal Head Position						Normal Head Position	Distance in Inches Above the Normal Head Position					
	6"	5"	4"	3"	2"	1"	0	1"	2"	3"	4"	5"	6"
75	70.5	70.6	70.8	71.2	71.4	71.6	71.8	71.7	71.8	72.1	72.3	72.3	72.5
125	77.2	77.6	77.8	77.8	78.0	78.2	78.5	78.5	78.7	79.0	79.2	79.4	79.6
250	84.3	84.3	84.1	83.6	83.4	82.9	82.8	82.6	82.4	82.0	81.8	81.6	81.5
500	89.4	89.3	89.1	89.0	88.9	88.6	88.6	88.5	88.5	88.6	88.6	88.7	88.8
1000	84.9	84.8	84.6	84.4	85.2	85.6	86.2	86.2	86.0	85.7	85.4	84.7	84.3
2000	85.6	85.8	85.5	84.6	84.0	84.2	84.8	84.9	84.8	84.4	84.0	84.4	85.0
3000	83.8	83.4	85.6	86.2	85.4	83.4	85.0	86.6	87.3	85.8	84.8	85.0	85.2
4000	84.1	85.0	84.8	85.4	87.8	87.0	85.2	85.4	84.6	84.4	84.8	84.0	82.1
6000	72.6	71.7	72.8	77.8	80.5	84.2	82.0	82.0	80.6	76.4	78.1	77.2	77.3
8000	79.2	78.0	77.9	81.1	81.8	83.4	83.6	84.2	85.1	82.4	84.4	81.1	83.0

Table II

Sound Pressure Level Gradient Data Derived from Measurements of Ten Test Tones in the IAC 1285-A Audiometric Room at the Acoustic Laboratory, Fort Rucker, Alabama. The Values are Normal Maximum Sound Pressure Level Output, in Decibels (re 0.0002 Dyne/cm^2), from the Calibrated Instrumentation for Testing Real-Ear Attenuation.

Test Tones in Hz.	Distance in Inches in Front of the Normal Head Position						Normal Head Position	Distance in Inches Behind the Normal Head Position					
	6"	5"	4"	3"	2"	1"	0	1"	2"	3"	4"	5"	6"
75	76.7	76.1	75.4	74.6	73.9	73.3	72.2	71.4	70.7	70.0	69.2	68.6	68.3
125	81.1	80.6	80.4	80.0	79.6	79.2	78.6	78.4	78.1	77.8	77.2	77.4	76.6
250	80.8	81.5	82.8	81.9	82.6	82.8	83.0	83.2	83.5	83.6	83.7	83.7	83.6
500	87.2	87.8	88.0	88.4	88.5	88.5	88.2	88.1	87.9	87.6	87.3	86.7	86.6
1000	86.0	84.6	83.4	83.7	84.7	86.0	86.6	86.5	85.8	84.6	83.3	82.4	82.5
2000	83.4	84.2	86.7	85.7	81.8	82.9	85.3	84.0	80.0	82.0	84.2	83.4	81.3
3000	82.6	83.8	83.4	83.6	85.3	82.0	82.6	80.2	78.8	83.3	79.5	84.4	85.8
4000	84.9	85.7	85.5	85.3	85.8	84.3	84.5	82.6	85.0	84.1	83.0	83.2	81.2
6000	78.0	81.4	80.6	77.8	79.0	81.2	82.8	72.6	77.8	80.8	82.0	75.0	77.8
8000	79.6	78.6	82.6	82.0	82.0	82.7	82.4	80.1	80.6	80.2	82.1	79.8	80.6

Table III

Sound Pressure Level Gradient Data Derived from Measurements of Ten Test Tones in the IAC 1285-A Audiometric Room at the Acoustic Laboratory, Fort Rucker, Alabama. The Values are Normal Maximum Sound Pressure Level Output, in Decibels (re 0.0002 Dyne/cm^2), from the Calibrated Instrumentation for Testing Real-Ear Attenuation.

Test Tones in Hz.	Distance in Inches Left of the Normal Head Position						Normal Head Position	Distance in Inches Right of the Normal Head Position					
	6"	5"	4"	3"	2"	1"	0	1"	2"	3"	4"	5"	6"
75	71.6	71.6	71.7	71.7	72.1	72.0	72.3	72.3	72.3	72.4	72.4	72.5	72.3
125	78.1	78.2	78.3	78.4	78.6	78.5	78.6	78.8	78.9	78.9	79.0	79.0	79.0
250	82.4	82.5	82.6	82.7	82.8	82.8	82.9	83.0	83.1	83.1	83.1	83.1	83.2
500	88.2	88.5	88.7	88.9	89.0	88.9	88.9	88.6	88.4	87.9	87.5	87.0	86.4
1000	85.2	85.7	86.1	86.4	86.6	86.3	86.0	85.4	84.7	84.1	83.6	83.4	82.6
2000	83.0	83.2	83.7	84.5	84.7	84.9	85.2	85.1	85.1	84.7	83.3	82.6	84.4
3000	84.7	82.9	82.5	80.9	80.8	82.3	84.6	86.2	85.2	82.6	81.2	82.4	85.0
4000	82.4	82.0	82.4	81.6	82.4	82.8	83.8	84.6	82.6	80.5	82.3	84.3	82.5
6000	82.5	81.3	82.5	82.5	77.1	73.4	82.0	81.7	74.4	79.5	83.0	78.1	84.8
8000	76.4	81.7	79.1	81.7	83.6	83.1	83.1	84.7	79.9	83.7	76.2	81.5	74.2

Table IV

Mean Sound Pressure Level and Standard Deviation Values in Decibels (re 0.0002 Dyne/cm^2) of Ambient Acoustic Noise in the Industrial Acoustics Company 1285-A Audiometric Room at the Acoustic Laboratory, Ft. Rucker, Alabama. Also Shown are System Noise Data of the Instrumentation Used in Measuring the Acoustic Noise.

1/3rd Octave-Band Center Frequencies in Hertz	System Noise		Room Noise	
	Mean SPL Equiv.	Standard Deviation	Mean SPL	Standard Deviation
25	18.13	3.15	29.36	2.97
31.5	16.13	2.80	28.68	3.07
40	16.00	2.90	29.48	2.95
50	14.76	2.42	30.36	2.55
63	15.83	2.12	31.97	1.52
80	12.87	2.17	14.36	1.95
100	11.38	1.70	16.81	0.37
125	9.70	1.75	28.93	0.85
160	9.32	1.50	9.88	1.25
200	8.02	1.42	10.99	1.22
250	6.14	1.25	17.81	1.22
310	5.58	1.32	11.56	0.67
400	4.86	1.17	14.21	0.32
500	4.18	0.82	4.58	0.95
630	2.65	1.22	4.46	0.80
800	2.08	0.90	4.55	0.90
1,000	1.59	0.60	2.40	1.12
1,250	2.68	1.20	4.17	0.65
1,600	1.26	1.00	3.22	1.22
2,000	0.96	1.22	2.18	0.95
2,500	0.31	1.27	1.78	0.27
3,150	0.73	1.22	8.97	0.80
4,000	0.58	1.25	4.16	0.47
5,000	1.46	0.80	2.53	1.15
6,300	1.75	0	2.98	1.15
8,000	2.35	1.07	1.90	0.60
10,000	1.75	0	4.30	1.72
12,500	2.49	1.15	4.25	0
16,000	4.25	0	4.26	0.15
20,000	4.25	0	4.62	0.87
A	36.75	0	36.75	0
B	34.25	0	35.65	1.25
C	46.75	0	49.32	0.70
Lin	56.75	0	56.75	0

Table V

Mean Real-Ear Sound Attenuation and Standard Deviation Values in Decibels Obtained with the Sierra Engineering Armored Vehicle Crewman Helmet, P/N 791

Test Frequencies in Hertz	Sierra AVC Helmet*		Mean Attenuation Values Required by Specifications
	Mean	Standard Deviation	Mean
75	15.97	5.83	
125	13.74	4.87	15
250	12.36	4.88	14
500	16.27	4.43	24
1000	25.18	6.03	28
2000	30.10	3.97	30
3000	34.68	4.02	35
4000	44.13	5.10	35
6000	40.51	6.24	35
8000	35.78	9.50	30

* Tests performed at USAARL - 10 subjects 3 times each.

equal to or greater than the specifications at test frequencies 2,000, 3,000, 4,000, 6,000 and 8,000 Hz. For test frequencies 125 Hz, 250 Hz, 500 Hz, and 1,000 Hz the mean attenuation values were less than those specified. For three of these frequencies, 125, 250 and 1,000 Hz, the differences were no greater than 3 decibels. The most significant difference was found at 500 Hz which was 7.73 decibels. This is significant in view of the standard deviation of 4.43 decibels.

The test results obtained with the Standard Method for the Measurement of the Real-Ear Attenuation of Ear Protectors at Threshold, ANSI Z24.22 - 1957, show that the Sierra P/N 791 AVC helmet failed to pass the required sound attenuation characteristics. Therefore, this helmet in its present configuration is not acceptable as a hearing protector for the U. S. Army tank crewmen.

SUMMARY AND CONCLUSIONS

At the request of the Preventive Medicine Division of the Office of The U. S. Army Surgeon General, the Aeromedical Research Laboratory assumed the task of obtaining a solution to the problem of severe hearing loss among U. S. Army tank crewmen caused by the adverse acoustical environment associated with tank operation. Three "off-the-shelf" helmets were submitted in 1970, one of which - the DH-132 - was selected as suitable for test and consideration as a replacement for the original CVC helmet. The DH-132 has been tested and approved as a standard helmet for the protection of the U. S. Army tank crewmen. In addition to this helmet, the Sierra P/N 791 AVC has been submitted for test and evaluation for consideration as a second standard helmet. The real-ear attenuation test results show that the Sierra helmet significantly failed the attenuation specifications and therefore did not meet the attenuation requirements established by The Surgeon General. The Sierra helmet in its present configuration is not acceptable as a hearing protector for U. S. Army tank personnel.

Dated: 4 June 1973

REFERENCES

1. Camp, Robert T., Jr. Real-Ear Sound Attenuation Characteristics of Three Brands of Ear Protective Devices Proposed for Armored Vehicle Crewmen. USAARL Letter Report, U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama, 25 May 1970.

2. McCurdy, Harry W.; Walden, Brian E.; and Worthington, Don W. The Extent of Hearing Loss in the Army. A Survey Report, Army Audiology and Speech Center, Walter Reed General Hospital, Washington, D.C., Year 1972.

3. Camp, Robert T., Jr.; Bailey, Robert W.; Mozo, Ben T.; Schott, Gordon A.; Guzdar, Rohinton N.; and Hinkel, Timothy M. Real-Ear Sound Attenuation Characteristics of the DH-132 Helmet for Armored Vehicle Crewmen. USAARL Report No. 73-8, U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama, February 1973.

4. Department of the Army Technical Bulletin TB MED 251, 25 January 1965. Noise and Conservation of Hearing.

5. American National Standards Institute. American Standard Method for the Measurement of the Real-Ear Attenuation of Ear Protectors at Threshold, ANSI Z24.22-1957.

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13. ABSTRACT

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